

INDIAN LSSC FACILITY

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ABSTRACT

The Indian Space Agency has undertaken a major project to acquire in-house capability for thermal and vacuum testing of large satellites. This large Space Simulation Chamber (LSSC) facility will be located in Bangalore and scheduled to be operational in 1989. The facility is capable of providing 4 meter diameter Solar Simulation with provision to expand to 4.5 meter diameter at a later date. With such provisions as controlled variations of shroud temperatures, and availability of infrared equipment as alternate sources of thermal radiation, this facility will be amongst the finest anywhere. This paper presents the design concept and major aspects of the LSSC which is currently under construction.

INTRODUCTION

A Large Space Simulation Chamber (LSSC) with 4-meter solar beam expandable to 4.5 meters is being erected at ISRO Satellite Center, Bangalore, India with projected completion in late 1989. This facility, upon completion, will be used for the purpose of solar simulation tests, thermal-vacuum tests, infrared mode thermal balance tests, and vacuum temperature tests on satellites. Besides these, the chamber may be used as vacuum temperature envelope for deployment tests of panels/antenna, Thermal cycling of solar panels, optical tests, and dynamic balancing of various space craft hardware.

SYSTEM DESCRIPTION

The baseline configuration of the LSSC consists of two-part 304 SS

chamber; the 9-meter diameter vertical main chamber and 7-meter diameter horizontal auxiliary chamber. The horizontal chamber is juxtaposed onto vertical chamber which will accept the test satellite mounted on a vibration isolation support platform via a motion simulator. The auxiliary chamber houses the collimating mirror, and the spout with chamber window provides interface with the lamphouse. The lamphouse houses lamp modules, transfer optics and the douser in a protected environment. The vacuum chamber is lined with shrouds through which nitrogen is circulated to attain temperature in the range of 100K to 373K. The entire facility is operated from a centrally located control console. There are six normal modes of the LSSC operation, and are described as follows:

Vacuum Mode:

This is for the purpose of dynamic balancing and other mechanical tests wherein the chamber shrouds remain at ambient, and the pressure is selectable at 1 mbar and 10^{-5} mbar. The main chamber shrouds are designed to be removable in order to gain larger working envelope in this mode.

Vacuum and Cryogenic Mode:

This mode is for the purpose of thermal tests in the infrared mode or eclipse situation wherein the chamber pressure is held less than 10^{-5} mbar, and the shrouds are held at 100K by means of recirculating subcooled LN₂.

Solar Simulation Mode:

In this mode the solar simulator is 'ON' under high vacuum conditions

with shroud temperature 100 K similar to the Vacuum and Cryogenic Mode.

Vacuum-Temperature/Thermal Vacuum Mode:

This mode is for thermal vacuum testing and bakeout wherein the shrouds can be maintained at any programmed temperature for any interval of time in the range of 173 K to 373 K under high vacuum conditions of less than 10^{-5} mbar. The Constant density GN₂ dense gas circulation system is provided to attain the desired temperatures.

Solar Simulation Calibration Mode:

This mode is for intensity distribution of the solar beam wherein the solar simulator is turned on under ambient temperature and pressure in the chamber.

Mirror Degas Mode:

In this mode, the collimating mirror housed inside the auxiliary chamber is heated/cooled from ambient to 393 K and back to ambient by means of GN₂ dense gas circulation system at the rate of 5K/hr. with the chamber shrouds lagging behind the mirror temperature.

DESIGN DESCRIPTION

The following provides some of the salient design features of various components/subsystems of the LSSC.

Chamber:

The design of the chamber is in accordance with ASME Sec. VIII/BS 5500. The 9-meter main chamber accommodates the test payload. The 7-meter auxiliary chamber housing the collimating mirror and the spout for solar beam entry is juxtaposed onto the main chamber. The 4-meter cutout for the main entry and provision for top loading of the test payload onto the motion simulator platform by means of an overhead crane are also provided in the main chamber. The chamber shell is made of 304L stainless steel, and all external stiffeners are A-36 steel, with inner surface polished to reduce contamination and minimize

heat in-leak. Provisions of illumination inside the chamber are made, operable under vacuum conditions to facilitate mechanical tests as well as CCTV monitoring operations.

Shrouds:

The shrouds are made of 304L stainless steel, single-embossed platecoil design. They are selected for ease of weldability and very low outgassing characteristics. Their outer flatside is electropolished to reduce emissivity thereby reducing heat in-leak from chamber walls, and the inner embossed side is glass-beaded and painted with flat black paint Sikksens 463-6-5. The shrouds are designed for maximum operating pressure of 100 psi, and can handle 100 KW internal load in conjunction with the LN₂ subcoolers. The shrouds are divided into 42 active flow controlled zones for temperature control of main and auxiliary chamber shrouds.

LN₂ & GN₂ System:

The LN₂ system is designed for heat dissipation of 100 KW inside the main chamber, with localized flux of 2KW/M². The LN₂ is circulated in sub-cooled condition by means of independent centrifugal pump systems for the main and auxiliary chamber shrouds.

The GN₂ system utilizes centrifugal blowers, maintaining constant density over entire working temperature by means of the active pressure control. The system is designed for 15KW heat load in the main chamber with localized heat flux of 1.4 KW/M². It is also capable of programmed warmup or cooldown of the shrouds in the temperature range of 100 K to 373 K at the rate of 1K/min.

Vacuum System:

A helium cold gas cryopanel, located in the 4-meter port of the main chamber, is used as the primary high vacuum pump with free N₂ pumping speed in excess of 250,000 l/sec. The helium cold gas refrigerator/liquifier is

capable of supplying 92 watts/39 liters of LHe per hours from a single RS-compressor with LN_2 precooling. Two 48" cryopumps, each with nominal pumping speed for N_2 of 55,000 l/sec. with chamber shrouds at ambient are also provided. In addition, two 2200 l/sec. turbomolecular pumps, are installed to handle light gases, and to form a part of the pressure reduction system for use in conjunction with the RGAs. The main roughing system comprising a pair of identical skids, are equipped with roots-type blower cascades backed with the sliding vane mechanical pumps. These roughing systems can pump down the chamber from ambient to 1 mbar in under $1\frac{1}{2}$ hours.

Solar Simulator:

The solar simulator consists of lamp modules, transfer optics and douser, all housed in a protected environment inside the lamphouse, and the main chamber window located in the spout along with the collimating mirror located inside the auxiliary chamber.

There are eleven 20-KW Xenon lamp modules for use with 4-meter beam size, which may be increased to fourteen 20-KW Xenon lamps to expand the beam to 4.5 meters. In either configuration the intensity range of 0.65 KW/M^2 to 1.7 KW/M^2 is provided with intensity uniformity of $\pm 4\%$ in the reference plane at the center of the main chamber.

The collimating mirror is fabricated as a mosaic of 55 hexagonal mirrors positioned onto the mirror support structure supported inside the auxiliary chamber on a kinematic mount. The mirrors are made of an aluminum alloy, diamond turned and subsequently aluminized and anti-reflection overcoated for protection. The mirrors and the support structure are held at ambient temperature except during the mirror degas mode.

Lamp modules, transfer optics and lamphouse panels are cooled by close-loop D.I. Water System exchanging heat with the facilities refrigerated water

supply.

Motion Simulator:

The motion simulator, fabricated from aluminum alloy, is designed to be installed on top of vibration isolation platform inside the main chamber. It is a two axis mount, providing tilt capability of $\pm 180^\circ$ and adjustable spin rate from 0 to 10 rpm with drift less than 0.05 rpm as accumulated over any 24-hour period. The simulator is designed to handle payloads up to 3,000 kg with static unbalance-up to 100 N.M. and physical size of 4-meter diameter x 4.5 meter long.

The motion simulator is equipped with shrouds to provide the same temperature as the surrounding main chamber shrouds, while its main structure is maintained at near ambient temperature for satisfactory operation of critical mechanical components, such as bearings, etc. The MLI blankets are utilized to thermally isolate the support structure from the motion simulator shrouds to affect the required design criteria.

Data Acquisition & Instrumentation Control System:

The LSSC test facility is a complex system consisting of the chamber vacuum system, shrouds and nitrogen circulation system, solar simulator and motion simulator along with auxiliary facilities, like LN_2 storage, etc. Each system has some parameters which require monitoring, processing and controlling in order to achieve the designed function. In addition, the space craft flight model, and subsystems within it require subjecting them to various tests within the chamber. In view of these requirements a computer based instrumentation control and data acquisition system has been implemented.

The overall system architecture includes the utilization of a 32-bit microprocessor as the primary host, and another such machine as the back up

host. The test satellite data acquisition is handled by four 16-bit monitor RTUs to provide capability for 1024 TC, 256 V, 256 I, 64 RTD, and 32 Strain data monitoring. Also forming a part of motion simulator is a 600 TC channel multiplexer located on the spin axis of the motion simulator. Four 16-bit Control RTU are employed to handle 128 infrared heaters, each handling 64 TC, 32 I and 32 V. The ninth 16-bit RTU is used to handle signals from thermal, vacuum, and auxiliary facilities systems.

The individual PLCs controlling thermal, vacuum and auxiliary facilities are connected directly with the host via the data highway. The PID loop controllers for shroud and mirror temperatures communicate with the host via RS-232C links, and with their dedicated processor through RS-422 links. The PLCs/microprocessors for the solar and motion simulators are also linked directly with the host.

Two operator terminals and four user terminals together with various numbers of dot matrix printers, line printers, video hard copiers, winchester, cartridge, mag tape and floppy drives constitute the peripheral equipment.

The PLCs along with the control and instrumentation and mimic panels are located in free standing control console which also provides the alarm and status of the total LSSC facility.

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(California) for solar simulator, Contraves Goertz Corporation of Pittsburgh (Pennsylvania) for the motion simulator and PSI Data System, Bangalore, for data acquisition hardware and software.

SUMMARY

The salient design concepts of the Indian LSSC, expected for completion in late 1989, will rank it amongst the best test facilities anywhere. It is equipped with solar, motion and infrared simulation capable of testing satellites up to 4 meters in size.

Session VI

SPACE SIMULATION II

